

Island, and Connecticut. It is, therefore, probable that the total amount taken on the coast north of Cape Hatteras is not less than 30,000,000 bushels annually, having a value of more than \$20,000,000. In making this estimate we should allow for the great increase in bulk and value of many of the Maryland and Virginia oysters that are transplanted to northern waters, and allowed to grow before using. The average value of the northern oysters, both native and transplanted, is probably more than seventy-five cents per bushel. It is, therefore, probable that the above estimate is considerably too low.

The great oyster-markets of the country are Baltimore and New York. In Baltimore immense quantities of oysters are put up in kegs and cans to supply the distant parts of our own country and also to ship to nearly all foreign countries. In 1867 it was estimated that more than 10,000 persons were employed in this branch of the business. There were then thirty packing-houses, employing 4,500 openers. In addition to the packing business great quantities of oysters are sold at Baltimore and sent away in the shell. The total quantity sold at Baltimore exceeded 7,000,000 bushels, of which about 5,000,000 bushels came from Maryland waters, and the balance from Virginia. Of these over 1,000,000 bushels were sent to New York, 700,000 to Fair Haven, Connecticut, where an extensive packing business is carried on, 450,000 to Philadelphia, 350,000 to Boston.

The oyster trade of New York, several years ago, was estimated at over \$8,000,000, employing 2,500 vessels, and it has greatly increased since that estimate was made.

Among the most common shells that are found attached to oysters are *Crepidula fornicata* (Plate XXIII, figs. 129, 129a) and *C. unguiformis*, (Plate XXIII, fig. 127.) They both occur together on the upper as well as the under valves, and in all cases retain their ordinary characters, except that the latter is more regular in form, and usually has the upper surface slightly convex, instead of being much distorted and with a concave upper surface, as the larger specimens that live on the inside of dead univalves usually are. Its color, when living on the oysters, is always white, while the *C. fornicata* is always more or less marked with brown.

The common muscle, *Mytilus edulis*, (p. 307) frequently occurs attached to oysters, and when it accumulates on the oyster-beds in large quantities it is very injurious. The *Modiola hamatus* (p. 374) is a very peculiar-looking muscle, having a broad, often hatchet-shaped, distorted shell, covered with prominent radiating ribs, many of which are forked. Its color is yellowish or brownish. It somewhat resembles *Modiola plicatula*, but is broader and has coarser ribs. This muscle is sometimes found in New Haven Harbor, living on the oyster-beds in considerable numbers, and of full size, attached to the oysters, either singly or in clusters, by the byssal threads. It has been observed only in the summer and fall and it may not have survived the winters, for it is possible

that all the individuals may have been brought from the south, in the spring, when quite small, attached to the oysters. It may be, however, that it has really become naturalized on our shores. It is very common in the Gulf of Mexico, and on other parts of the southern coast. The *Anomia glabra* (p. 311, Plate XXII, figs. 241, 242, 242a) is also very commonly found adhering to oysters.

The hard sandy tubes of *Sabellaria vulgaris* (p. 321, Plate XVII, figs 88, 88a) and the calcareous tubes of *Serpula dianthus* (p. 322) are very frequent upon oyster-shells, and occasionally those of *Potamilla oculifera*, (p. 322, Plate XVII, fig. 86,) *Scionopsis palmata*, (p. 321,) and other species are met with. Many other Annelids are to be found burrowing or hiding beneath the oysters. The common green star-fish, *Asterias arenicola*, (p. 326, Plate XXXV, fig. 269,) occasionally occurs on the oyster-beds near the mouths of estuaries, but is seldom sufficiently abundant in the brackish waters to do serious damage to the oyster-beds.

In the brackish waters the "drill," *Urosalpinx cinerea*, (p. 306, Plate XXI, fig. 116,) is the worst enemy of the oyster, and is sometimes so numerous as to do very serious damage.

Several species of Hydroids grow adhering to oysters. The most abundant of these, in brackish water, is usually *Halecium gracile* V., (p. 328,) but two or three species of *Obelia* and some other forms occur.

Of Bryozoa, one of the most common species is the *Escharella variabilis*, (p. 312, Plate XXXIII, fig. 256,) which forms calcareous incrustations. The *Bugula turrita*, (p. 311, Plate XXXIV, figs 258, 259,) and *Vesicularia dichotoma* V. (p. 404) are also common. The *Alcyonidium hirsutum*, (p. 404,) which forms soft fleshy crusts over the surface of the shells, is quite frequently seen.

The common red sponge (p. 330) is often abundant on the oyster-beds where the water is not much freshened.

*List of species inhabiting oyster-beds in brackish waters.*

ARTICULATA.

*Insects.*

	Page.
<i>Chironomus oceanicus</i> .....	379

*Crustacea.*

	Page.		Page.
<i>Pinnotheres ostreum</i> .....	367	<i>E. longicarpus</i> .....	313
<i>Cancer irroratus</i> .....	312	<i>Crangon vulgaris</i> .....	339
<i>Panopeus Herbstii</i> .....	472	<i>Mysis Americana</i> .....	370
<i>P. Sayi</i> .....	312	<i>Melita nitida</i> .....	314
<i>P. depressus</i> .....	312	<i>Ampelisca</i> , sp.....	431
<i>Carcinus granulatus</i> .....	312	<i>Unciola irrorata</i> .....	340
<i>Libinia canaliculata</i> .....	368	<i>Corophium cylindricum</i> ....	370
<i>Eupagurus pollicaris</i> .....	313	<i>Epelys trilobus</i> .....	370

*Annelids.*

	Page.		Page.
Lepidonotus squamatus....	320	Cirratulus grandis.....	319
L. sublevis .....	320	Sabellaria vulgaris.....	476
Phyllodoce, sp.....	349	Cistenides Gouldii.....	323
Eulalia, sp.....	349	Nicolea simplex.....	321
Eteone, sp.....	349	Scionopsis palmata.....	476
Podarke obscura.....	319	Polycirrus eximius.....	320
Nereis virens.....	317	Chætobranchus sanguineus.	320
N. limbata.....	318	Potamilla oculifera.....	476
Marphysa Leidy.....	319	Sabella microphthalma....	323
Lumbriconereis opalina....	320	Fabricia Leidy.....	323
Rhynchobolus Americanus.	319	Serpula dianthus.....	476
R. dibranchiatus.....	319	Spirorbis, sp .....	323

*Nemerteans and Planarians.*

	Page.		Page.
Nemertes socialis.....	324	Monocelis agilis.....	325
Cosmocephala ochracea....	325	Procerodes frequens.....	325
Polinia glutinosa.....	324		

*Nematodes.*

	Page.		Page.
Pontonema marinum.....	325	P. vacillatum.....	326

## MOLLUSCA.

*Gastropods.*

	Page.		Page.
Urosalpinx cinerea .....	476	Odostomia fusca.....	307
Fulgur carica.....	355	O. trifida.....	307
Sycotypus canaliculatus...	355	O. bisuturalis.....	307
Ilyanassa obsoleta .....	354	Crepidula fornicata.....	475
Astyris lunata .....	306	C. unguiformis.....	475
Rissoa aculeus.....	306	C. convexa.....	355
Littorinella minuta.....	469	Doridella obscura.....	307
Bittium nigrum.....	305		

*Lamellibranchs.*

	Page.		Page.
Venus mercenaria .....	469	Modiola hamatus.....	475
Argina pexata.....	309	Pecten irradians .....	361
Scapharca transversa.....	309	Anomia glabra.....	476
Mytilus edulis.....	475	Ostræa Virginiana.....	472

*Ascidians.*

	Page.		Page.
Cynthia partita .....	311	Molgula Manhattensis.....	311

*Bryozoa.*

	Page.		Page.
Bugula turrita .....	476	Vesicularia dichotoma.....	476
Escharella variabilis.....	476	Aleyonidium hirsutum.....	476
Membranipora lineata .....	406	Pedicellina Americana.....	405

## RADIATA.

*Echinoderms.*

	Page.
Asterias arenicola.....	476

*Acalephs.*

	Page.		Page.
Obelia gelatinosa.....	391	Halecium gracile.....	476
O. diaphana .....	327	Sertularia argentea.....	408
O. pyriformis .....	390		

*Polyps.*

	Page.		Page.
Metridium marginatum....	329	Sagartia leucolena.....	329

## PROTOZOA.

*Sponges.*

	Page.		Page.
Tedania, species.....	330	Red branching sponge.....	476
Halichondria, sp.....	330		

## III. 4.—ANIMALS INHABITING EEL-GRASS IN BRACKISH WATERS.

A large portion of the shallow parts of nearly all the harbors, estuaries, and ponds is occupied by a dense growth of eel-grass, *Zostera marina*, in summer. This plant flourishes both on sandy and muddy bottoms. During the fall and winter it is mostly torn up and drifted away by storms, but in the spring a new crop starts up and grows very rapidly, the narrow, ribbon-like leaves often becoming six feet or more in length during the summer.

These tracts of eel-grass are the favorite resorts of a considerable number of animals, which seek these places either for food or concealment and shelter, or for both combined. Other species, including certain hydroids, bryozoa, and ascidians, grow attached to the leaves of the eel-grass.

Many small fishes frequent the patches of eel-grass, and find there abundance of food and unusual safety from their enemies.

Among the most common Crustacea found among the eel-grass are the edible crab, *Callinectes hastatus*, (p. 367;) *Panopeus Sayi*, (p. 312;) *P. depressus*, (Plate I, fig. 3;) *Eupagurus longicarpus*, (p. 313;) the prawn, *Palæmonetes vulgaris*, (p. 369, Plate II, fig. 9;) the common shrimp, *Crangon vulgaris*, (p. 339, Plate III, fig. 10;) the green shrimp, *Virbius zostericola*, (p. 369, Plate III, fig. 11;) *Mysis stenolepis*, (p. 370, Plate III, fig. 12;) *M. Americana*, (p. 370;) *Idotea irrorata*, (p. 316, Plate V, fig. 23;) *Melita nitida*, (p. 314.) The common prawn (Plate II, fig. 9) has its true home among the eel-grass, and here it occurs in countless numbers. Its translucent body, marked with irregular, ill-defined, dark blotches and spots, admirably adapts it for concealment among the discolored and dead leaves of the plant, at or near the bottom.

Where the eel-grass grows on sandy bottoms the common shrimp is scarcely less abundant. The *Virbius* is often abundant, associated with the common prawn, and having similar habits. All these shrimps and prawns are eagerly devoured by the fishes. The *Idotea irrorata* is generally very abundant, and clings firmly to the leaves of the eel-grass lengthwise. Its body is generally curiously and variously colored with green and brown, &c., and these colors are often so arranged as to imitate very perfectly the colors of the eel-grass when partially dead or discolored. Sometimes the right or left half of the body will be bright green, while the opposite half will be dark brown. In other cases there will be a dorsal bright green stripe, while the sides will be dark brown, just like one of the leaves of the eel-grass that is discolored at the edges, but green in the middle. More commonly these colors are irregularly disposed in blotches.

The *Erichsonia attenuata* HARGER, is a remarkably slender species, which also lives clinging to the eel-grass. Its colors are green and brown, and quite variable.

Several species of Amphipods are also abundant among the eel-grass. One of the most common of these is the *Gammarus mucronatus*, (p. 466,) which is easily distinguished by the dorsal teeth on the abdominal segments. *Microdeutopus minax* SMITH, is a very small species, which sometimes occurs in great abundance in the small brackish ponds. It is remarkable for its relatively large and very broad hands, armed beneath with three prominent teeth. The hands are nearly as large as the entire body.

Among the Mollusks several interesting species occur. The *Ilyanassa obsoleta*, (p. 371, Plate XXI, fig. 113;) *Bittium nigrum*, (p. 305, Plate XXIV, fig. 154;) and *Astyris lunata*, (p. 306, Plate XXI, fig. 110,) are generally the most abundant species. The *Nassa vibex* (p. 371, Plate XXI, fig. 114) is met with occasionally, living on and about the roots of eel-grass, but it is an uncommon shell in our waters, though quite abundant on the southern coasts. The *Crepidula convexa* (p. 371, Plate XXIII, fig. 128)

may be found, both adhering to the leaves of eel-grass and attached to shells occupied by the smaller hermit-crabs.

The curious little naked mollusk, *Elysiella catulus*, (Plate XXV, fig. 171,) is often quite common on the leaves of eel-grass in our harbors. It also has the power of floating with the bottom of the foot at the surface of the water. Its small size and bright green color, like that of the growing leaves of the *Zostera*, cause it to be easily overlooked.

The related species, *Elysia chlorotica*, (Plate XXV, fig. 172,) appears to have similar habits, but is much less common. Its color is also green. The pretty *Doto coronata* (p. 400, Plate XXV, fig. 170) also occasionally occurs on the leaves of eel-grass.

A green Planarian is frequent on the eel-grass, and also a bright red species.

*List of species inhabiting the eel-grass in brackish waters.*

ARTICULATA.

*Insects.*

	Page.
<i>Chironomus oceanicus</i> .....	379

*Crustacea.*

	Page.		Page.
<i>Panopeus depressus</i> .....	479	<i>Melita nitida</i> .....	479
<i>P. Sayi</i> .....	479	<i>Microdeutopus minax</i> .....	479
<i>Callinectes hastatus</i> .....	479	<i>Amphithoë valida</i> .....	315
<i>Carcinus granulatus</i> .....	312	<i>A. longimana</i> .....	370
<i>Libinia canaliculata</i> .....	368	<i>A. compta</i> .....	370
<i>L. dubia</i> .....	368	<i>Corophium cylindricum</i> ....	370
<i>Eupagurus longicarpus</i> ....	479	<i>Caprella geometrica</i> .....	382
<i>Crangon vulgaris</i> .....	479	<i>Idotea irrorata</i> .....	479
<i>Virbius zostericola</i> .....	479	<i>Erichsonia attenuata</i> .....	479
<i>Palæmonetes vulgaris</i> .....	479	<i>Epelys trilobus</i> .....	370
<i>Mysis stenolepis</i> .....	479	<i>Balanus eburneus</i> .....	381
<i>M. Americana</i> .....	479	<i>Limulus Polyphemus</i> .....	340
<i>Gammarus mucronatus</i> ....	479		

*Annelids.*

	Page.		Page.
<i>Lepidonotus squamatus</i> ....	320	<i>Nicolea simplex</i> .....	321
<i>Podarke obscura</i> .....	319	<i>Scionopsis palmata</i> .....	321
<i>Autolytus cornutus</i> .....	397	<i>Polycinus eximius</i> .....	320
<i>Nereis limbata</i> .....	318	<i>Spirorbis, sp.</i> .....	323

*Nemerteans and Planarians.*

	Page.		Page.
<i>Polinia glutinosa</i> .....	324	Planarian, (red sp.).....	480
<i>Cerebratulus, sp.</i> .....	324	Planarian, (dark green sp.) .	480

## MOLLUSCA.

*Gastropods.*

	Page.		Page.
<i>Illyanassa obsoleta</i> .....	479	<i>Littorinella minuta</i> .....	469
<i>Nassa vibex</i> .....	479	<i>Crepidula convexa</i> .....	479
<i>Astyris lunata</i> .....	479	<i>Doto coronata</i> .....	480
<i>Anachis avara</i> .....	306	<i>Elysia chlorotica</i> .....	480
<i>Bittium nigrum</i> .....	479	<i>Elysiella catulus</i> .....	480
<i>Triforis nigrocinctus</i> .....	305		

*Lamellibranchs.*

	Page.		Page.
<i>Argina pexata</i> .....	309	<i>Pecten irradians</i> .....	361
<i>Mytilus edulis</i> .....	470	<i>Ostræa Virginiana</i> .....	472

*Ascidians.*

	Page.		Page.
<i>Molgula Manhattensis</i> .....	311	<i>Botryllus Gouldii</i> .....	375

*Bryozoa.*

	Page.		Page.
<i>Bugula turrita</i> .....	311	<i>Escharella variabilis</i> .....	312
<i>Vesicularia dichotoma</i> .....	404	<i>Membranipora, lineata</i> .....	406

## RADIATA.

*Acalephs.*

	Page.		Page.
<i>Obelia diaphana</i> .....	327	<i>Hydractinia polyclina</i> .....	328
<i>Obelia, sp</i> .....	476		

*Polyps.*

	Page.
<i>Sagartia leucolena</i> .....	329

## III. 5.—ANIMALS LIVING ON OR AMONG PILES OF WHARVES, BRIDGES, FLOATING TIMBER, ROCKS, ETC., IN BRACKISH WATERS.

The piles of wharves in brackish harbors are often inhabited by an abundance of animal life. The same species are mostly to be found also on piles of wharves in the purer waters of the sounds, and many of them have, therefore, already been mentioned in a previous place, (p. 378.) There are some of these species, however, that appear to flourish best in waters that are decidedly brackish.

Among the most conspicuous of these is the beautiful Tubularian

*Parypha crocea*, (p. 390, Plate, XXXVI, fig. 274,) which grows in large tufts, several inches in height, and often covers large surfaces of the piles and timbers at and just below low-water mark. Associated with this the *Obelia gelatinosa* (p. 391) often occurs in large quantities. This is a large and very beautiful species, having a large dark colored stem, composed of numerous united tubes, but the terminal branches are white and delicate, and the cells have an elegant bell-shaped form, with a toothed margin. It grows to the length of a foot or more. This species occurs on the piles of Long Wharf, in New Haven Harbor, in great abundance, associated with the preceding; at this place the water is not only quite brackish, but is very impure, on account of sewerage, &c.

Other species of *Obelia* also occur in similar places. The *Balanus eburneus* is a very abundant barnacle in brackish waters, growing upon piles, timbers, oyster-stakes, and every other kind of fixed wood-work, and also upon the bottoms of vessels and floating timber. As already remarked (p. 381) it is capable of living even in fresh water. The *Balanus balanoides* also occurs where the water is less brackish. The piles and timbers of the wharves are often badly damaged by the perforations of *Teredo navalis* (p. 384, Plate XXVI, fig. 183) even where the water is very brackish.\*

The *Limnoria lignorum* (p. 379) also attacks wood-work in waters that are somewhat brackish.

*Lists of species inhabiting piles of wharves, floating timbers, &c., in brackish waters.*

#### ARTICULATA.

##### *Insects.*

	Page.		Page.
Chironomus oceanicus.....	331	Anurida maritima.....	331

##### *Crustacea.*

	Page.		Page.
Panopeus depressus.....	312	Jæra copiosa.....	315
Microdeutopus minax.....	479	Idotea irrorata.....	316
Amphithoë compta.....	370	Limnoria lignorum.....	482
Corophium cylindricum....	370	Balanus balanoides.....	482
Caprella, sp.....	316	B. eburneus.....	482

\* Since the account of the *Teredo navalis*, on page 384, has been in type, I have learned some additional facts in regard to it from Mr. V. N. Edwards. The statement that the buoys are taken up every six months does not apply to the spar-buoys, which are taken up only once a year, in April and May. Mr. Edwards states that the *Teredos* would destroy an unpainted spar-buoy in one year, but when painted with verdigris they will only work where the paint becomes rubbed off. They grow to full size in one year. They first attack buoys or piles just below the water's edge, but eventually will destroy the entire submerged part of the spar-buoys. He thinks that some of them live through the winter.



*Annelids.*

	Page.		Page.
Nereis limbata.....	318	Potamilla oculifera.....	322
Autolytus cornutus.....	397	Sabella microphthalma....	323
Sabellaria vulgaris.....	321	Fabricia Leidy.....	323
Nicolea simplex.....	321	Serpula dianthus.....	322
Polycirrus eximius.....	320	Spirorbis, sp.....	323

*Turbellarians.*

	Page.		Page.
Monocelis agilis.....	325	Nemertes socialis.....	324
Polinia glutinosa.....	324		

*Nematodes.*

	Page.		Page.
Pontonema marinum.....	325	P. vacillatum .....	326

## MOLLUSCA.

*Gastropods.*

	Page.		Page.
Bela plicata .....	383	L. palliata .....	305
Ilyanassa obsoleta.....	468	Odostomia bisuturalis.....	307
Tritia trivittata.....	354	Bittium nigrum.....	305
Urosalpinx cinerea.....	306	Cerithiopsis Greenii.....	383
Astyris lunata.....	306	Triforis nigrocinctus.....	305
Anachis avara.....	306	Alexia myosotis .....	383
Rissoa aculeus.....	306	Melampus bidentatus.....	469
Skenea planorbis .....	383	Æolidia pilata .....	383
Littorina rudis .....	305		

*Lamellibranchs.*

	Page.		Page.
Teredo navalis.....	482	Modiola plicatula.....	307
Argina pexata .....	309	Anomia glabra.....	311
Mytilus edulis .....	307	Ostræa Virginiana .....	310

*Ascidians.*

	Page.		Page.
Molgula Manhattensis.....	311	Botryllus Gouldii.....	389
Cynthia partita.....	311		

*Bryozoa.*

	Page.		Page.
Vesicularia dichotoma.....	389	Bugula turrita .....	311
Escharella variabilis.....	312	Pedicellina Americana.....	405

## RADIATA.

*Hydroids.*

	Page.		Page.
Obelia gelatinosa.....	482	Halecium gracile.....	328
O. pyriformis .....	390	Parypha crocea .....	482
O. diaphana .....	327		

*Polyps.*

	Page.		Page.
Sagartia leucolena.....	329	Metridium marginatum....	329

## IV.—FAUNA OF THE OCEAN SHORES AND OUTER COLD WATERS.

All along this coast, from Cape Cod to Stonington, Connecticut, there is a belt or current of cold water which impinges directly against the outer islands and the open coast, especially where there are points of land projecting outward toward the deeper waters. This is especially noticeable at Gay Head, on Martha's Vineyard, No Man's Land, Cuttyhunk Island, Montauk Point, Block Island, Point Judith, and Watch Hill. This cold water is undoubtedly derived from the Arctic current, which passes slowly southward in deep water off our coast, but whether an actual current, distinguishable from the tidal currents, exists in the waters of moderate depth along the coast is still uncertain. The tidal currents apparently have the effect of bringing the cold water of the outside regions up into the shallower localities along the shores, and it is probable that the presence of the cold water in moderate depths is due to the joint action of the tides and the slow-moving Arctic current, which impinges more or less against and upon the slope of the submerged eastern border of the continent. But the position, extent, and temperature of this cold water along our shores varies greatly, according to the direction of the tidal currents and the surface currents caused by the wind. We have shown, on a former page, that at times these local winds and tidal currents are able even to bring Gulf Stream water and its characteristic animals directly upon this coast, even as far westward as Watch Hill, Rhode Island, where the *Physalia* is often cast ashore in summer. At such times the cold current must necessarily be wholly displaced, or disguised by intermixture with the warmer waters. When the tide is flowing from Long Island Sound, Vineyard Sound, or other large bodies of warm water, the cold waters will also be displaced and the temperature raised even at the distance of twenty or thirty miles from the shore in summer. In winter there is comparatively little effect from the Gulf Stream, owing to the prevalence of northerly winds, and there is also far less effect from the warm waters of the shallow bays and sounds carried by the tides. Therefore the full effect of the northern current is felt only in winter, and it doubtless adds to the cold proper to the season and land climate.

In winter and early spring we accordingly find numerous species of northern animals and algæ which disappear partially or wholly in many

of these localities in summer. In April, May, and June, the cod and haddock resort in large numbers to the banks and reefs off Stonington, Watch Hill, No Man's Land, and other similar places, but are quite unknown there later in the summer.

In consequence of the varying temperatures of the currents which alternately pass over certain of these localities, there is a very peculiar admixture of northern and southern species, side by side. This is particularly the case on the reefs between Watch Hill and Fisher's Island, where the southern *Astrangia Danae* is associated with the northern *Alcyonium carneum*, *Cribrella sanguinolenta*, and many other northern forms.

The temperature of the bottom-water during the last of August and first of September was found to vary from 57° F. to 63°, in sixteen to twenty-nine fathoms off Martha's Vineyard and Buzzard's Bay, (see chart.) The surface temperatures were at the same time 62° to 64°, and occasionally as high as 67°, when affected by warmer currents.

#### IV. 1.—SPECIES INHABITING ROCKY SHORES OF THE OPEN COAST.

The principal localities under this head at which we have made collections are No Man's Land, Cuttyhunk Island, Gay Head, and Watch Hill, Rhode Island. Dr. J. E. Leidy has published a partial list of the species found at Point Judith,\* and we have more or less information concerning the fauna of several other similar localities. In all these places the assemblage of animals is nearly the same, and in general not very different from what we find on the rocky shores of the sounds and bays, (see p. 303.) A large part of the species of these shores have, therefore, already been mentioned in connection with the fauna of the bays and sounds.

There are, however, many species that are characteristic of the latter, which are found but rarely, or not at all, on the colder and more exposed outer shores; and these are characterized by the abundance of some northern species which are rare or wanting on the inner shores, or which occur there only in winter.

Among the most abundant species of shells are *Purpura lapillus*, (p. 306, Plate XXI, figs. 118, 119;) *Littorina palliata*, (p. 305, Plate XXIV, fig. 138;) *L. rudis*, (p. 305, Plate XXIV, fig. 137;) *Acmaea testudinalis*, (p. 307, Plate XXIV, figs. 158, 159;) and *Lacuna vineta*, (p. 305, Plate XXIV, fig. 139,) all of which occur adhering to the rocks or algæ, even in the most exposed situations. These are all hardy northern species, which extend their range to Greenland or beyond, and although all of them are to be found, more or less frequently, on the inner shores, they are there less abundant and generally of smaller size. The *Littorina palliata* is extremely abundant on the *Fucus*, and individuals were found at Watch Hill, copulating, April 12. The *Lacuna vineta* breeds still

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\* Journal of the Academy of Natural Sciences of Philadelphia, 2d series, vol. iii, 1855.

earlier in the season, for its eggs were found attached to algæ and eel-grass at the date named. The eggs of this species are small, yellowish white, imbedded in a gelatinous mass, having an annular form, but showing a break or suture on one side. These annular egg-masses are attached by one side to the surfaces of flat algæ or eel-grass in large numbers; they are from .12 to .20 of an inch in diameter.

The *Æolis papillosa* was found at Watch Hill, under stones, April 12, and with it were long, much convoluted, gelatinous cords, filled with minute pale red or salmon-colored eggs, which probably belong to this species, which is a northern one, and has not hitherto been recorded as from south of Cape Cod. It is very abundant in the Bay of Fundy, and similar egg-clusters are found there under rocks during the entire summer.

Among and between the stones the northern purple star-fish, *Asterias vulgaris* (p. 432) is often found at low-water, and also the green sea-urchin, *Strongylocentrotus Dröbachiensis* (p. 406, Plate XXXV, fig. 268) during the spring tides.

The *Balanus balanoides* (p. 305) is quite as abundant on the most exposed rocks as elsewhere. The minute bivalve young of this species were found just attaching themselves to the lower surfaces of rocks in immense numbers at Watch Hill on the 12th of April.

Beneath the stones the rock-crab, *Cancer irroratus*, (p. 312,) is very common, and occasionally the much rarer *Cancer borealis* is found dead on these shores. It was thus found at Gay Head and No Man's Land, but it is doubtful whether it lives above low-water mark. In the lower part of the fucus zone the large *Gammarus ornatus* (p. 314, Plate IV, fig. 15) is always to be found in great abundance under stones, and in the upper half of the fucus zone the smaller species, *Gammarus annulatus* (p. 314) and *Gammarus marinus* often occur in great numbers, associated with *Jera copiosa* (p. 315) and *Idotea irrorata* (p. 316, Plate V, fig. 23.) The *Gammarus marinus* occurs higher up than either of the other species, and is sometimes abundant even near high-water mark, where the soil beneath the stones is barely moist at low-water. The *Amphithoë maculata* (p. 315, Plate IV, fig. 16) is also a common species under stones; and both green and reddish brown varieties occur.

Another species of *Amphithoë*, of smaller size, was found swimming free in the rocky pools at Watch Hill, April 12. In this the general color was red, or brownish red; the body was transversely banded with pale flesh-color or whitish, alternating with bands of dark red or brown, which are made up of minute crowded specks; the antennæ are annulated with pale red, and are thickly specked, on the bands and at the base, with darker red. The *Hyale littoralis* (p. 315) is a small but very active Amphipod, which is often abundant near high-water mark on the rocky shores, clinging to the *Fucus* and other algæ, or swimming in the tide-pools. It is capable of leaping actively like the beach-fleas, (*Orchestia*

*agilis*,) which it somewhat resembles in form. The color is very variable; it is often bright yellowish green, but frequently dark green, brownish green, or brown.

The *Nereis virens* (p. 317, Pl. XI, figs. 47–49) is very abundant in burrows beneath the rocks. The males of this species, six to ten inches or more in length, and of a dark green color, were found at Watch Hill, April 12, in great numbers, swimming about in the pools of water among the rocks, with an undulatory motion, and discharging their milt in large quantities. Various other Annelids burrow or build tubes beneath the stones. *A. planaria* and *Leptoplana folium* creep over their lower surfaces.

Attached to the stems of *Fucus* at low-water, several Hydroids may usually be found, but the *Sertularia pumila* (p. 327, Pl. XXXVII, fig. 279) is by far the most abundant. The *Obelia geniculata* is also very common, attached to *Laminaria* and other algæ. Various Bryozoa occur attached to stones and to *Fucus* and other algæ. The *Alcyonidium hispidum* (p. 312) is one of the most abundant species, and usually invests the stems and fronds of *Fucus vesiculosus*, but also often covers broad surfaces of the rocks. The *A. hirsutum* is often associated with the preceding species on the rocks; it forms broad, thin, soft crusts, covered with small soft prominences, but is without the spines or bristles seen in the latter. The Zoöids are also much smaller.

The *Farrella familiaris* is a singular and delicate species, which occurs both on the under side of rocks and on algæ. The body is small, fusiform, attached by a long and very slender, flexible pedicel. When it surrounds the stems of small algæ, the whitish pedicels project outward in all directions, and thus produce the appearance of a delicate chenille-cord. This is a northern and European species. It was also dredged on Saint George's bank in 1872.

*List of species found on the outer rocky shores.*

ARTICULATA.

*Crustacea.*

	Page.		Page.
Cancer irroratus.....	486	Gammarus marinus .....	486
Cancer borealis .....	486	Amphithoë maculata.....	486
Panopeus depressus.....	312	Amphithoë, sp.....	486
Panopeus Sayi.....	312	Caprella, sp.....	316
Homarus Americanus.....	492	Jæra copiosa.....	486
Orchestia agilis .....	315	Idotea irrorata.....	486
Hyale littoralis .....	486	I. phosphorea.....	316
Calliopius læviusculus.....	315	Erichsonia filiformis.....	316
Gammarus ornatus.....	486	Balanus balanoides....,	486
Gammarus annulatus.....	486		

*Annelids.*

	Page.		Page.
Lepidonotus squamatus.....	320	Cirrhinereis fragilis.....	397
Harmothoë imbricata.....	321	Clymenella torquata.....	343
Phyllodoce cantenula.....	494	Polycirrus eximius .....	320
Eteone robusta.....	349	Sabellaria vulgaris.....	321
Autolytus cornutus.....	397	Potamilla oculifera.....	322
Nereis virens.....	487	Fabricia Leidyi .....	323
N. pelagica.....	319	Serpula dianthus.....	322
Ophelia simplex.....	319	Spirorbis, sp.....	323

*Turbellaria.*

	Page.		Page.
Planaria, species .....	487	Nemertes socialis.....	324
Leptoplana folium.....	487	Nemertes, sp.....	498
Procerodes frequens.....	325	Monocelis agilis.....	325

*Nematodes.*

	Page.		Page.
Pontonema marinum.....	325	Pontonema vacillatum.....	326

## MOLLUSCA.

*Gastropods.*

	Page.		Page.
Buccinum undatum.....	494	L. neritoidea.....	495
Tritia trivittata.....	354	Bittium nigrum.....	305
Urosalpinx cinerea.....	306	Acmæa testudinalis .....	485
Purpura lapillus.....	485	Doris bifida.....	307
Astyris lunata .....	306	Polycera Lessonii.....	400
Littorina palliata.....	485	Dendronotus arborescens...	495
L. rudis .....	485	Æolis papillosa.....	486
Lacuna vineta .....	485	Tergipes despectus.....	495

*Lamellibranchs.*

	Page.		Page.
Saxicava arctica.....	309	Mytilus edulis .....	307
Mya arenaria .....	309	Modiola modiolus.....	309
Kellia planulata .....	310	Anomia glabra.....	311

*Ascidians.*

	Page.		Page.
Cynthia partita.....	311	Amarœcium pellucidum....	401
Molgula Manhattensis.....	311		

*Bryozoa.*

	Page.		Page.
<i>Aleyonidium hirsutum</i> .....	487	<i>Bugula flabellata</i> .....	311
<i>A. hispidum</i> .....	487	<i>Membranipora pilosa</i> .....	406
<i>Vesicularia gracilis</i> .....	389	<i>M. lineata</i> .....	406
<i>V. cuscuta</i> .....	404	<i>Escharella variabilis</i> .....	312
<i>V. fusca</i> .....	420	<i>Discopora coccinea</i> .....	333
<i>Farrella familiaris</i> .....	487	<i>Lepralia, sp.</i> .....	420
<i>Tubulipora flabellaris</i> .....	405	<i>Cellepora ramulosa</i> .....	312
<i>Crisia eburnea</i> .....	311	<i>Pedicellina Americana</i> .....	405

## RADIATA.

*Echinoderms.*

	Page.		Page.
<i>Strongylocentrotus Dröbachi-</i>		<i>Asterias vulgaris</i> .....	496
<i>ensis</i> .....	496	<i>Cribrella sanguinolenta</i> ....	407

*Acalephs.*

	Page.		Page.
<i>Obelia pyriformis</i> .....	390	<i>Sertularia pumila</i> .....	487
<i>O. geniculata</i> .....	487	<i>S. argentea</i> .....	408
<i>O. flabellata</i> .....	390	<i>Pennaria tiarella</i> .....	327
<i>O. diaphana</i> .....	327	<i>Clava leptostyla</i> .....	328
<i>Campanularia flexuosa</i> .....	327	<i>Hydractinia polyclina</i> .....	228

*Polyps.*

	Page.		Page.
<i>Metridium marginatum</i> .....	329	<i>Sagartia leucolena</i> .....	329

## IV. 2.—SPECIES INHABITING THE SANDY SHORES OF THE OPEN COAST.

Owing to the force of the waves the sand and gravel of the exposed shores are kept in constant motion in stormy weather, and are often disturbed to a considerable depth, especially in winter. Therefore the conditions are very unfavorable for the existence of animal life. The fauna of such shores is, accordingly, very meager, as compared with that of the more sheltered sandy shores of the bays and sounds.

It often happens that one may examine these sandy beaches for a mile or more at low-water without finding more than half a dozen species of animals that actually live on them, though many may be found thrown up by the waves from below low-water mark.

In coves or other localities that are somewhat sheltered, the number of species is greater, and most of them are identical with those found on the sandy shores of the sounds.

Toward high-water mark the *Talorchestia longicornis* (p. 336) and *T.*

*megalophthalma* (p. 336) are everywhere common, burrowing in the sand. The *Cancer irroratus* (p. 338) and *Platyonichus ocellatus* (p. 338) are rather common at and just below low-water mark. The *Hippa talpoida* (p. 338, Plate II, fig. 5) is occasionally found, and the young sometimes occur in large numbers, burrowing in the sand at low-water mark. The common shrimp, *Crangon vulgaris*, (p. 339, Plate III, fig. 10,) is usually abundant where there are sheltered sandy flats.

The Annelids are less numerous than on the sandy shores of the sounds, but such as do occur are mostly of the same species. One of the most interesting is the *Nerine agilis*, (p. 346,) which is very remarkable for the rapidity with which it burrows in the sand.

The Mollusks are few in number. One of the most abundant of the Gastropods is the *Lunatia heros*, (p. 353, Plate XXIII, figs. 133-136,) which burrows just beneath the surface of the sand, at and below low-water mark. The *Neverita duplicata* (p. 354, Plate XXIII, fig. 130) is also occasionally found, but is much less abundant than in the bays.

Of Lamellibranchs there are but few species that can maintain themselves in such situations. Among these the "long clam," *Mya arenaria*, (p. 463,) the "razor-shell," *Ensatella Americana*, (p. 356,) and the "surf-clam," *Macra solidissima*, (p. 358,) are the most common.

Very few, if any, Radiates are to be found on the exposed sandy shores, unless thrown up by the waves from deeper water. In places that are somewhat protected from the violence of the surf, the *Leptosynapta Girardii* (p. 361, Plate XXXV, figs. 265, 266) is often found burrowing in the sand at low-water mark. Sometimes, in similar places, the "sand-dollar," *Echinarachnius parma*, (p. 362, Plate XXXV, fig. 267,) is found in large numbers at extreme low-water mark.

There are no Hydroids and Polyps that properly inhabit such shores.

*List of species inhabiting the sandy shores of the open coast.*

ARTICULATA.

*Crustacea.*

	Page.		Page.
Ocypoda arenaria, (young)...	337	Crangon vulgaris.....	490
Cancer irroratus .....	490	Orchestia agilis .....	336
Cancer borealis.....	486	Talorchestia longicornis....	489
Platyonichus ocellatus.....	490	T. megalophthalma.....	489
Hippa talpoida.....	490	Unciola irrorata.....	340
Eupagurus pollicaris .....	313	Idotea cæca.....	340

*Annelids.*

	Page.		Page.
Nereis virens .....	317	Scolecopsis viridis.....	345
N. limbata.....	318	Clymenella torquata.....	343
Rhynchobolus Americanus..	342	Amphitrite ornata .....	320
Nerine agilis.....	490	Polycirrus eximius .....	320



## MOLLUSCA.

*Gastropods.*

	Page.		Page.
Sycotypus canaliculatus . . . .	399	C. unguiformis . . . . .	354
Tritia trivittata . . . . .	354	Lunatia heros . . . . .	490
Crepidula fornicata . . . . .	355	Neverita duplicata . . . . .	490

*Lamellibranchs.*

	Page.		Page.
Ensotella Americana . . . . .	490	Mya arenaria . . . . .	490
Siliqua costata . . . . .	426	Mactra solidissima . . . . .	490

## RADIATA.

*Echinoderms.*

	Page.		Page.
Leptosynapta Girardii . . . . .	490	Echinarachnius parma . . . . .	490

## IV. 3.—ANIMALS INHABITING ROCKY BOTTOMS OFF THE OPEN COAST.

The fauna of the rocky bottoms in these outer waters is rich and interesting, and decidedly northern in character, though there is usually an admixture with southern species.

The principal localities where dredgings were made on this kind of ground are: First, off Gay Head and Devil's Bridge, at localities marked on the chart, 53, *a, b, c, d*; 55, *a, b, c*; 56, *a, b, c, d*; 57, *a, b, c, d*; 58, *a, b, c*; 59, *a, b, c*; 60, *a, b, c*; 61, *a, b, c*; 62, *a, b, c*; 63, *a, b*; 83, *a, b, c*. Second, between Gay Head and No Man's Land, and to the westward of the latter island, at localities 82, *a, b*; 84, *a, b, c, d*; at these localities cod are caught in the spring. Third, on and about the rocky reef extending from Watch Hill, Rhode Island, to Fisher's Island, and forming, in part, the physical boundary of the eastern end of Long Island Sound; this is also a locality where cod and haddock are caught in spring. The dredgings at this place were made by Professor D. C. Eaton, Mr. C. A. Burt, and myself, April 13, 1873. Fourth, a locality off Cuttyhunk Island, where dredgings were made, April, 1872, by Mr. T. M. Prudden, Mr. T. H. Russell, and others.

The four localities named are characterized by a similar fauna, but each one yielded some species not found in the others, though more numerous dredgings might have revealed them. The reef off Watch Hill is of peculiar interest on account of the singular blending of the northern and southern faunæ at that place, as mentioned above. It seems to be nearly at the extreme western range of many northern species, though some of them may occur sparingly in certain favorable localities still farther westward, in Long Island Sound itself. Many northern algæ were also collected there by Professor Eaton, in abund-

ance, and some of them have not been found farther westward, and others but rarely. Among these were *Ptilota elegans* and *Delesseria sinuosa*, both of which were abundant on the reef in four or five fathoms, associated with large quantities of *Phyllophora Brodiaei*, and *P. membranifolia*; *Euthora cristata* and *Lithothamnion polymorphum* also occurred. The "dulse," *Rhodymenia palmata*, *Laminaria digitata*, *L. saccharina*, and *L. longicirura*, all of which are decidedly northern species, were large and abundant.

A similar assemblage of algæ was also found on the rocks, in shallow water, off Gay Head, though some of the species just named were not found there.

Among the Crustacea of these localities, the most important is the lobster, *Homarus Americanus*, (p. 395,) which finds its proper habitat in such places. It is very abundant off Gay Head, and among the reefs and rocks off Watch Hill and Stonington, Connecticut. It also occurs plentifully in similar localities off New London, Connecticut, and still farther west in Long Island Sound. At all these and many other localities large quantities are caught for the markets. They are nearly all taken in "lobster pots" baited with refuse fish, &c.

The lobster fishing begins in this region in the latter part of March or early in April, according to the season. By the middle of April they are usually taken in large quantities and shipped alive to New York, New Haven, and other cities. The extent of this trade is enormous even in this region, while north of Cape Cod, along the whole northern coast of New England, and on the shores of Nova Scotia, the lobster is taken in still larger quantities. At present we have no reliable data for estimating the number annually caught, but it probably amounts to several millions.

In winter the supply comes from the northern coasts of Massachusetts and Maine, where they may be taken in moderately deep water at all seasons. According to Captain N. E. Atwood\* they do not come into shallow water at Provincetown until June and remain there until October, when they disappear again. He also states that those that visit that locality are nearly all females; "they appear to come near the shore for the purpose of depositing their young, after which they pass away and others in turn take their places, as is indicated by the change that is constantly taking place, for when the fishermen are catching great quantities of large, good hard-shell lobsters, and they are unusually abundant, perhaps the next day there will be a new kind, smaller and not of so good quality, the former ones having passed away and others come to take their places." "In Boston the number of lobsters sold annually cannot be much short of a million. The male lobster is preferred and is the most salable, as this city has always been supplied from the northern shore of Massachusetts and coast of Maine, where the

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\* Proceedings Boston Society of Natural History, vol. x, p. 11, 1866.

males are most plentiful. It is a great advantage to the fishermen that the people prefer males. In New York it is very different in this particular, that city being supplied from Cape Cod after June, and the female lobster thus considered much the best. I have sold many lobsters in New York, and males sell at only about half price; the male is much poorer than the female in meat." Captain Atwood states, in the same place, that northward and eastward of Plymouth, Massachusetts, "three-quarters at least are males at all seasons of the year." Among those that I have examined from New London, Waterford, and Stonington, Connecticut, in our markets, I have not noticed any marked inequality in the number of the sexes. Mr. Smith examined the lobsters in the market at Provincetown on two occasions in August and September, without finding any decided differences in the number of males and females. He also repeatedly examined those in the fish-markets at Eastport, Maine, in summer, with the same result. It is possible therefore, that the fishermen do not correctly distinguish the sexes, when the females are without eggs, and that an erroneous opinion has thus become current among them.

There is a great difference in the breeding season on different parts of the coast. The lobsters from New London and Stonington often lay their eggs as early as the last of April or first of May; while at Halifax, Mr. Smith found females with recently laid eggs in September. At Eastport, Maine, the females carry their eggs in mid-summer. In the male the genital orifices are in the bases of the last pair of legs; in the female they are at the bases of the middle pair. This will always serve to distinguish the sexes, but they also differ in the structure of the abdominal appendages.

The rock-crab, *Cancer irroratus*, (p. 312,) is very common on these bottoms, and *C. borealis* (p. 395) also inhabits them, judging from the large dead specimens found on the adjacent beaches, but we only dredged a few small living specimens. One of these was taken on the reef between Watch Hill and Fisher's Island, in 4 or 5 fathoms, among algæ. It is more convex, and much more hairy than the preceding species, and the teeth along the sides of the carapax are quite different.

A large and handsomely colored shrimp, *Pandalus annulicornis* (Plate II, fig. 6,) often occurs in the deeper waters, outside, but is far more common farther north, as in the Bay of Fundy. The common shrimp, *Crangon vulgaris*, (p. 339, Plate III, fig. 10,) is common, especially where there are spots of sand among the rocks. The little bright-colored shrimp, *Hippolyte pusiola*, (p. 395,) is frequently met with among the red algæ. The *Unciola irrorata*, (p. 340, Plate IV, fig. 19,) and *Amphithoe maculata*, (p. 315, Plate IV, fig. 16,) together with several other Amphipods, are common, especially among the red algæ, and some of them are handsomely marked with red and other bright colors.

Among these are *Podocerus fucicola*, which is a small species and quite variable in color; some of those from the reef at Watch Hill had a

transverse dorsal band of red or orange on each segment, and similar ones on the epimera, and were minutely specked with dark brown; the antennæ and legs were annulated with white and light red or orange. Another species of *Podocerus* was still more abundant among the red algæ; in this the males and females differ greatly in size, form, and color. The females are much smaller and stouter than the males; their colors were generally red and white, in strong contrast, though some were purplish and more like the males in color; most of the females have the head and few anterior segments dark red; then a band of white; then three or four bands of dark red, on the middle of the body, which are often confluent into a large dorsal spot of red or brown; these are followed by a broad white band or spot; the abdominal rings are alternately banded with red and white; part of the epimera are red. The antennæ and legs are more or less annulated and spotted with red. The eyes are black. In the male the color is generally reddish or purplish brown, but irregularly specked with darker brown, and with the intervals between the segments pale red.

Species of *Caprella* occur in considerable numbers, clinging, in grotesque attitudes, upon the delicate algæ and hydroids. The *Idotea irrorata*, (p. 316, Plate V, fig. 23,) is also very common, living among the algæ, and *Erichsonia filiformis* (p. 316, Plate VI, fig. 26,) is often associated with it.

The Annelids living upon such bottoms are difficult to obtain, since they mostly burrow beneath the stones or live in tubes attached to the rocks. The few species obtained are, with few exceptions, not different from those found in the sounds, on similar bottoms. The *Autolytus cornutus*, (p. 397, Plate XIII, figs. 65, 66,) and another species of the same genus were found in abundance, living in tubes attached to the fronds of *Laminaria* among hydroids, (*Obelia geniculata*.) On the same fronds were long, crooked tubes, formed of grains of sand and small bits of shells, belonging to *Nicolea simplex*, (p. 397.)

Burrowing in the corals of *Astrangia Danæ* we found, on the reef off Watch Hill, the singular Annelid named *Naraganseta coralii* by Dr. Leidy, who obtained his specimens at Point Judith. The specimens found by us were mostly very dark greenish brown or black, but some had dark, orange-colored branchiæ. The *Lepidonotus angustus*, *Phyllodoce gracilis*, *P. catenula*, and *Eumidia Americana* are new and interesting species. *Nereis fucata* occurs rarely.

Of Gastropods many species already enumerated as inhabitants of the rocky shores occur also on the rocky bottoms in abundance, but there are a number of additional species. One of the largest is the "whelk," *Buccinum undatum*, (Plate XXI, fig. 121.) This is a decidedly northern and arctic shell, found also on all the northern coasts of Europe, though several authors believe that the American and European shells are distinct species.

One of the most interesting of the northern shells that occur here is